

**National Aeronautics and Space Administration  
Washington, DC**

**NASA ADVISORY COUNCIL**

**Human Exploration and Operations Committee**

**July 28-29, 2014**

**Langley Research Center  
Hampton, Virginia**

**MEETING MINUTES**

---

**Ken Bowersox, Chair**

---

**Bette Siegel, Executive Secretary**

**Human Exploration and Operations Committee  
Langley Research Center  
Hampton, Virginia  
July 28-29, 2014**

**MEETING MINUTES  
TABLE OF CONTENTS**

Call to Order.....	2
Opening Remarks.....	2
Joint Session with NAC Science Committee.....	2
Space Launch System and Discussion.....	4
Joint Discussion of Findings and Recommendations.....	5
Center Welcome and Remarks.....	6
Human Exploration and Operations Status and Plans.....	6
Status of Commercial Crew.....	9
Status of International Space Station.....	10
Public Comments and Inputs.....	10
Discussion and Recommendations.....	11
Wrap Up.....	13
Public Comments.....	13
Appendix A	Agenda
Appendix B	Committee Membership
Appendix C	Attendee List
Appendix D	List of Presentation Material

**Meeting Minutes Prepared By  
David J. Frankel, Consultant  
P B Frankel, LLC**

**NASA ADVISORY COUNCIL  
HUMAN EXPLORATION AND OPERATIONS COMMITTEE  
Langley Research Center  
Hampton, VA**

**PUBLIC MEETING  
July 28-29, 2014**

**July 28, 2014**

Call to Order

Dr. Bette Siegel, Executive Secretary for the NASA Advisory Council (NAC) Human Exploration and Operations (HEO) Committee, called the joint public session of the HEO Committee and the NAC Science Committee meetings to order at 9:30 a.m. Dr. Jens Feeley, Executive Secretary for the Science Committee was introduced. Dr. Siegel announced that the meeting was a Federal Advisory Committee Act (FACA) meeting and, therefore, open to the public. Minutes would be taken and posted on-line, together with the presentations. There would be an opportunity for the public to make comments towards the end of the meeting. Dr. Siegel explained that the reason for the joint session is that the NAC Work Plan includes a requirement to show how the Science Mission Directorate (SMD) and HEO Mission Directorate (HEOMD) are working together and to explore whether there are opportunities on the Space Launch Systems (SLS) for science experiments.

Opening Remarks

Dr. Siegel introduced Mr. Ken Bowersox, HEO Committee Chair, who welcomed everyone to the meeting. He noted that the NAC Work Plan had assigned a joint action to the HEO and Science Committees to assess the current state of interaction and cooperation between the Human Space Flight (HSF) and robotic science mission organizations. The Committees would be briefed on the status of joint operations between the two organizations and would also be given an overview on the SLS. Mr. Bowersox introduced Dr. David McComas, Science Committee Chair. Dr. McComas noted and thanked Mr. Bowersox for having travelled to San Antonio, Texas to meet with him to prepare for the meeting. At Dr. McComas' request, the members from each Committee introduced themselves. In addition to the Committee members, also introducing themselves were Dr. John Grunsfeld, Associate Administrator, SMD, Mr. Bill Hill, Deputy Associate Administrator, Exploration Systems Development Division (ESD), HEOMD, and Mr. Greg Williams, Deputy Associate Administrator for Policy and Plans, HEOMD. Dr. McComas observed that all robotic exploration is really human exploration because robots do not discover anything, people do.

Joint Session with NAC Science Committee

Mr. Bowersox introduced Dr. James Green, Director, Planetary Science, SMD. Dr. Green briefed the Committees on joint activities between HEOMD and SMD. He noted that there has been steady and significant progress over the last six years. A chart was presented on Exploration destinations. The International Space Station (ISS), at 220 miles from Earth, was shown on the chart as the destination for Human Space Operations. The destinations for Human Space Exploration are the Moon (239,000 miles), Lagrange Point L2 (274,000 miles), near-Earth asteroids (3,100,000 miles), and Mars (34,600,000 miles). Europa, 390,400,000 miles from Earth was shown as a destination for Robotic Science.

Dr. Green reviewed activities that serve both Science and Exploration. He described the Lunar Reconnaissance Orbiter (LRO). He noted that it is continuing to perform outstanding research at the Moon and that locating robotic landing sites on the Moon is still important. Laser communications from the Moon were tested on the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission. The Asteroid Redirect Mission (ARM) was described. It has three segments: identify, redirect, and explore. SMD is working to identify and characterize the target asteroid; ground and space-based telescopes are being used for this purpose. He described NASA's Near Earth Object (NEO) Search Program. A chart was presented to show the number and size of Earth asteroids that have been discovered. The complementary capabilities of the Goldstone and Arecibo planetary radar observatories were discussed.

Mars missions in the current decade were shown on a chart and described. Mars Odyssey's Mars Radiation Environment Experiment (MARIE) collected data on the radiation environment in interplanetary cruise and Mars orbit to help assess potential risks to future human explorers. The Mars Phoenix Lander addressed investigations in the Mars Exploration Program Analysis Group (MEPAG) Goal IV (Humans 2 Mars), answering science questions and Strategic Knowledge Gaps (SKGs). Dr. Green explained that an SKG is an unknown or incomplete data set that contributes cost risk to future human Mars missions. The Mars Science Laboratory (MSL) was discussed. Its Radiation Assessment Detector (RAD) characterizes the radiation environment on Mars surface. The MSL's Mars Entry, Descent, and Landing (EDL) Instrument (MEDLI) measured the atmospheric conditions and performance of the MSL heatshield during entry and descent. A slide was shown on the location of Landers and Rovers on Mars. A chart was presented on potential global ground-water resources on Mars. Dr. Green described the Mars 2020 Rover. It will conduct rigorous *in situ* science, while seeking signs of life on Mars. MEDLI-2 for Mars 2020 was described. It will provide improved aerodynamics, thermal resolution, and for the first time, backshell measurements. Terrain Relative Navigation, enabling precision landing, was discussed.

Dr. Green described research and analysis activities. Charts were presented on the Solar System Exploration Research Virtual Institute (SSERVI) teams and work products. Future joint activities were described; these include work on EDL, the Atomic Clock, and Ion Engines.

Dr. Maura Hagan asked how new SKGs would be addressed if they are uncovered. Dr. Green answered that they are discussed in various assessment groups and that it is an on-going process. In response to a question from Dr. Mark Robinson on why new technologies should not be tested on the Moon, Dr. Green noted that lunar missions could be used for that purpose. Dr. Pat Condon asked whether NASA has identified areas where SKGs could be worked on by international partners. Dr. Green responded that each assessment group includes international members, which enables NASA to become familiar with the international partners' research and missions.

In response to a question from Dr. McComas, Dr. Green commented that he was the prime division-level contact in SMD for HEOMD matters. Dr. McComas noted he had been surprised that Dr. Green had been selected as the presenter for the topic because his (Dr. McComas') vision was broader than planetary science; he expected the presentation to address all cooperation between SMD and HEOMD, including Earth Science and the ISS. Dr. Green explained that he had provided the view from the perspective of Planetary Science. Dr. Siegel noted that other activities had not been covered, including planetary protection; however, Planetary Science constituted the major area for cooperation. Dr. Grunsfeld identified himself as the overall lead for cooperation between SMD and HEOMD and explained that Dr. Green leads the Planetary Science area for that cooperation. He noted that there has been a significant

amount of activity on the ISS in Astrophysics and Earth Science, and there is a potential for activity in the future in Heliophysics. Dr. McComas explained that the task assigned to the Committees by the Administrator is broader than Mars. He noted that working together requires money from both sides, and he asked how the contributions were tracked.

In response to a query from Mr. Bowersox, Mr. Williams described how the three Directorates are working together on the ARM. SMD is leading the asteroid detection, identification, and characterization effort. Space Technology Mission Directorate (STMD) is leading the Solar Electric Propulsion (SEP) module development. HEOMD has been leading the full concept definition activity. The ARM as a pre-formulation concept is led by Mr. Robert Lightfoot, NASA Deputy Administrator. Mr. Lightfoot has a Mission Program Director, Dr. Michele Gates, who is a HEOMD employee on a one year detail to Mr. Lightfoot to lead the concept studies and the mission concept review. The bulk of the budget is in HEOMD and STMD. In the fall, there will be formal mission program assignments for the mission's development, and a single Directorate will be put in charge.

Dr. McComas thanked Dr. Green for his presentation.

#### Space Launch System and Discussion

Mr. Bowersox introduced Mr. Bill Hill, Deputy Associate Administrator for ESD, HEOMD, who introduced Mr. Stephen Creech, Deputy Manager, SLS Spacecraft/Payload Integration and Evolution. Mr. Hill noted that ESD is excited about providing a capability for bringing science to the outer planets. He explained that the more customers SLS has, the more that SLS's cost can be lowered.

Mr. Creech reviewed a slide showing the SLS's evolutionary path to future capabilities. It minimizes unique configurations and allows incremental development. The Block 1 configuration will have a capability to launch a 70 metric ton payload. The Block 2 configuration will have a capability to launch a 130-metric ton payload. By comparison, the Saturn rocket had a 120-metric ton capability. Mr. Creech explained that the SLS is available for space science launches beginning in 2017. It has a five-meter payload fairing that allows for payload envelopes compatible with current Evolved Expendable Launch Vehicles (EELVs). A chart showing SLS development milestones was reviewed. The benefits SLS offers to space science were described. It has a greater mass lift capability than any launch vehicle in the world. Its payload fairings provide the greatest available volume. Its high departure energy can be used for missions throughout the solar system and beyond. The high departure energy enables SLS to offer faster transit time to destinations or an increase in mass. In response to a question from Dr. McComas, Mr. Creech explained that the Mars mission requirements are driving the increased payload volume in the Block 2 configuration.

A chart was presented on the SLS's evolved performance characteristics. Case studies were discussed for the Advanced Technology Large Aperture Space Telescope (ATLAST) and the Europa Clipper. Europa exploration was identified as a high priority in the "Visions and Voyages" Planetary Science Decadal Survey. The SLS can provide direct injection to Jupiter, eliminating several years of planetary gravity assists and reducing flight time to Europa from 6.3 years to 2.7 years. Additional benefits are reduced operational costs, reduced mission risk, and greater mass margin. Dr. McComas commented that Science pays for its own vehicles and that very often the cost savings drives a decision to use a slower vehicle. Mr. Creech explained that the goal is to make the SLS cost neutral. A chart was presented on outer planet EELV trajectories. Mr. Creech discussed SLS secondary payload capability. Dr. Robinson

asked whether NASA would be re-starting production of the RS-25 rocket motor or replacing it. Mr. Creech responded that that was under consideration. He explained that the facility that we built the engines in, including a unique asset that was used to manufacture the nozzles, has been shut down. *We are looking at ways to modify production of the RS-25 to reduce costs and replace previously used capabilities, such as nozzle production.* Dr. Robinson noted that the historical cost was approximately \$50 million (M) per engine. He explained that the engine would be single use, even though the engine had been used multiple times on the Space Shuttle. Mr. Creech described the Asteroid Redirect Robotic Mission (ARRM). He noted that additional information on the SLS is available at [www.nasa.gov/SLS](http://www.nasa.gov/SLS).

Dr. McComas and Mr. Bowersox thanked Mr. Hill and Mr. Creech for their time and presentation.

#### Joint Discussion of Findings and Recommendations

Dr. McComas read the task under consideration by the two Committees that had been specified by the Administrator in the 2014 Work Plan for the NASA Advisory Council:

*Human and Robotic Mission Cooperation: Assess the current state of interaction and cooperation between the human space flight and robotic science mission organizations, including but not limited to use of ISS, suborbital reusable launch vehicles, and short duration orbital platforms/cubesats. Provide recommendations to improve process, utilization, and outcomes as appropriate. As the capabilities for exploration (Space Launch System, Orion and ARM mission planning) mature and the Agency prepares to send humans to Mars in the 2030s, assess the opportunities for future collaboration to take advantage of the capabilities offered by both the NASA Human Exploration and Operations Mission Directorate and Science Mission Directorate, and provide recommendations to improve synergy between human and scientific exploration and advance Agency goals.*

Dr. Steven Running commented that Earth Science is always concerned about the cost to get sensors into space. He asserted that the SLS has no real relevancy. Dr. Douglas Duncan commented that if cost requirements were not met, the SLS would not find customers. Dr. Grunsfeld noted that the SLS cadence was very low compared to the Space Shuttle experience. Other than Europa and a notional large telescope, he did not see many ways to help improve the cadence. Mr. Bowersox noted that one of the biggest problems is competing with commercial providers and that the SLS takes opportunities away from people who are working hard to develop a commercial capability. Mr. Williams commented that national capabilities are another big issue. He noted that one could imagine a scenario where SMD budget may be required to contribute only what an Atlas 5 would have cost to SLS launches; in any case, it all is paid for in the Agency budget, and it will be an agency-level decision. Mr. Richard Malow explained that a Europa mission will probably fly on the SLS because it has a very strong supporter “on the other end of Pennsylvania Avenue.” Mr. Williams noted that SLS is looking at the intelligence community as a potential customer. Mr. James Odom commented that the SLS launch rate will end up being crucial to the safety of missions. Dr. Condon stated that SMD and HEOMD have initiatives and activities that overlap, and they should cooperate and bend to accommodate the needs of the other. Dr. Hagan requested additional information on cooperation between SMD and HEOMD in areas beyond Planetary Science. Dr. Robinson commented that the SLS must fly three or four Orion flights a year to be sustainable. Mr. Hill noted that the development of exploration systems cannot be sustained on maximum \$3 billion (B) a year and have sufficient funding to develop additional capabilities needed to push further into the universe.

Dr. McComas requested a report showing the funds contributed by SMD and HEOMD to joint projects. Dr. Robinson asked for additional information on the power and space available for SLS science payloads. Mr. Hill suggested including the STMD in the analysis. Dr. McComas commented that findings or recommendations should be prepared at a subsequent joint meeting. Dr. Running noted that the huge volumes available on the SLS would enable a meaningful relaxation on design requirements for fold-out antennas. Many missions have been canceled due to the cost of radar antennas. Dr. Harlan Spence suggested holding a workshop to pull together ideas from the science community. Dr. Grunsfeld noted that workshops had been held following the announcement of "Moon, Mars, and Beyond," and he suggested that results from those workshops could be updated. Dr. Carle Pieters, participating telephonically, noted that she echoes the comments concerning cost and cadence. She recommended that the next joint meeting include a discussion across the different NASA divisions about long-term issues that have cost impacts.

#### Center Welcome and Remarks

Mr. Bowersox introduced Mr. Stephen Jurczyk, Director, Langley Research Center (LaRC). Mr. Jurczyk welcomed everyone to the Center. He explained that he has been the Center's Director since May and that there has been an effort to integrate exploration and science where it makes sense.

Mr. Bowersox thanked Mr. Jurczyk for his time and for hosting the meeting.

#### HEO Status and Plans

Mr. Bowersox introduced Mr. Greg Williams, Deputy Associate Administrator for Policy and Plans, HEOMD, NASA Headquarters (HQ). Mr. Williams briefed the HEO and Science Committees on NASA's Human Exploration Strategy. He noted that the strategy has evolved over the past two months. Mr. Bowersox commented that if the Committee could not give a complete endorsement on the entire strategy it would identify aspects that it could endorse. Mr. Williams explained that NASA is guided by the U.S. National Space Policy and the 2010 NASA Authorization Act, which direct NASA, in pertinent part, as follows:

##### *US National Space Policy*

- *"Set far-reaching exploration milestones. By 2025, begin crewed missions beyond the moon, including sending humans to an asteroid. By the mid-2030s, send humans to orbit Mars and return them safely to Earth;"*
- *"Maintain a sustained robotic presence in the solar system to: conduct scientific investigations of other planetary bodies; demonstrate new technologies; and scout locations for future human missions;"*

##### *2010 NASA Authorization Act*

- *"The long term goal of the human space flight and exploration efforts of NASA shall be to expand permanent human presence beyond low-Earth orbit and to do so, where practical, in a manner involving international partners."*
- *"Finding (1) The extension of the human presence from low-Earth orbit to other regions of space beyond low-Earth orbit will enable missions to the surface of the Moon and missions to deep space destinations such as near-Earth asteroids and Mars."*
- *"Finding (7) Human space flight and future exploration beyond low-Earth orbit should be based around a pay-as-you-go approach..."*

Building from those two documents, the NASA Strategic Plan was developed. It provides, in pertinent part, the following goal and objectives:

- Goal 1: Expand the frontiers of knowledge, capability, and opportunity in space.
- Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.
- Objective 1.2: Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity.
- Objective 1.3: Facilitate and utilize U.S. commercial capabilities to deliver cargo and crew to space.

Mr. Williams explained that “pay as you go” is a driver to the Capability Driven Framework. Mr. Tommy Holloway commented that humans in a Mars orbit can operate robots on Mars’ surface easier than from Earth due to the time lapse. Dr. Condon asserted that the policy to go to orbit, then try to figure out what to do is “totally backwards.” Mr. Williams asserted that it is not necessary for a strategy to match a budget; rather, a strategy is needed to define budget objectives. However, a plan that does not match the budget is not a plan. Mr. Holloway advised that the costs must be dramatically reduced. He asserted that 30 percent of the acquisition costs are “self-inflicted.” He suggested bringing commercial business into the Exploration Program as a way to reduce costs.

Mr. Williams discussed the concept of “Pioneering Space,” which he defined as moving beyond low Earth orbit (LEO) into the solar system with long term purpose and multiple partners. He reviewed six key strategic principles to provide a sustainable program:

- implementable in the near-term with the buying power of current budgets and in the longer term with budgets commensurate with economic growth;
- application of high Technology Readiness Level (TRL) technologies for near term missions, while focusing sustained investments on technologies and capabilities to address challenges of future missions;
- near-term mission opportunities with a defined cadence of compelling human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
- opportunities for U.S. commercial business to further enhance the experience and business base learned from the ISS logistics and crew market;
- multi-use, evolvable space infrastructure; and
- substantial international and commercial participation, leveraging current ISS partnerships.

Mr. Bowersox suggested including science and communication in the strategic principles. Mr. Williams agreed that those should be made explicit. Mr. Holloway suggested including cost reduction.

Mr. Williams discussed the Evolvable Mars Campaign (EMC). The EMC’s guiding philosophy:

- leverages strong linkage to current investments in ISS, SLS, Orion, ARM, technology development investments, and science investments;



- starting in the Proving Ground, through the cis-lunar environment, enabling science along the way, and providing infrastructure for human exploration missions beyond Mars;
- accommodates the budget, both in escalation and peaks coupled with a cadence of missions;
- emphasizes prepositioning and reuse/repurposing of systems when it makes sense;
- “provides a basis for architecture development and identification and analysis of trade studies with our partners and stakeholders and incorporates the flexibility to adjust to changing priorities across the decades. From this work will emerge the roadmap we will follow through cis-lunar space to pioneer Mars.” (from the “Pioneering Space” paper); and
- not to develop “the plan” but develop different options to provide a range of capability needs to be used as guidelines for near term activities and investments.

The different trades that must be considered for the EMC were reviewed. These trades take place in three domains: in the Proving Ground phase (cis-lunar space); in the Earth Independent phase (Mars vicinity); and trades that apply “across the board,” (both Proving Ground and Earth Independent, as well as the current Earth Reliant phase in which we are operating in low-Earth orbit). A slide was presented showing the EMC’s capability and mission extensibility. Slides depicting Mars split mission concepts were discussed. SEP would be used for transporting cargo, and chemical propulsion would be used to provide more rapid crew transportation.

Mr. Williams reviewed the ARM. It has three components: identify potential target asteroids, redirect the target asteroid to cis-lunar space with SEP, and explore the asteroid using SLS-launched crew who would return with samples in the Orion spacecraft. Mr. Williams described the ARM’s objectives and explained how the ARM fits into NASA’s Exploration Strategy. He described two alternatives being considered for the ARM’s second segment. Option A calls for a small asteroid to be captured and redirected to a stable orbit in cis-lunar space. Option B calls for landing on a large asteroid and removing a small boulder, then redirecting it to a stable orbit in cis-lunar space. Potential candidate asteroids for each option were described. The development and risk reduction status for each option were also described. Mr. Bowersox asked how it would be known whether the rock would come loose in Option B. Mr. Williams explained that a target boulder would be characterized optically and by radar in order to ascertain its density, which would inform whether it is loose or more coherent. Mr. Joseph Cuzzupoli commented that NASA will not have money to fly the mission. He added that science needs to get instruments to NASA on time. He reported that Russia is preparing to go to the Moon, and he questioned the reason for NASA not going back to the Moon.

Charts were presented to show STMD work in FY 2014 on solar array technology and electric propulsion. The crewed mission segment design and development was discussed. A chart was presented on ARM risk reduction for future Mars and deep space missions. Mr. Williams discussed a chart showing the ARM milestones for Mission Concept Review (MCR). The down-select between Option A and Option B is scheduled for mid-December 2014, and the MCR is scheduled for February 2015.

Mr. Williams presented a slide showing Human Exploration pathways. In response to a question from Mr. Bowersox, Mr. Williams explained that the difference between a flexible path approach and a pathways approach is the focus on picking the pathway early. He noted that the National Research Council (NRC) approach was very strong on picking the pathway early and then taking it off-ramp if it did not work. Mr. Bowersox commented that the pathway approach would require early consensus on a pathway and decision rules. Mr. Williams noted that both approaches focus on the same destinations. He explained that the NRC believed that its approach had the best chance for long-term support that would span subsequent administrations. NASA’s approach, on the other hand, recognizes the

importance of learning and trade studies along the way that may change the pathway. It makes more sense, therefore, to “march down the path” of what is called the capability driven framework, recognizing that Mars is the horizon goal pulling NASA forward. Mr. Bowersox commented that, in an ideal world, the plan described in the NRC report would be best; however, taking political realities into consideration, setting up a 30-year plan with rigid decision criteria would be too hard to execute, whereas NASA’s plan is realistic. Dr. Condon asserted that the budget would never materialize and that there is a need to make the argument for why human presence on Mars’ surface makes sense. In response to a question from Dr. Condon, Mr. Williams noted that there are some areas in the NRC’s report that are valuable and some that NASA takes issue with; however, the report has not had the immediate impact that he expected. Mr. Malow commented that based on the Augustine report, NASA would need \$3B more than it is receiving.

Mr. Williams discussed a chart on EMC forward work. The chart lists trades to be considered “across the board,” cis-lunar trades, and Mars vicinity trades. He reviewed several charts that compared findings and recommendations from the 2009 Augustine Report, the 2014 NRC Report, and the 2013 Global Exploration Roadmap (GER) on exploration philosophy, destinations, leveraging current assets, and science and technology development.

Mr. Bowers and Dr. McComas thanked Mr. Williams for his presentation. The Science Committee members adjourned to a separate meeting.

#### Status of Commercial Crew

Mr. Bowersox introduced Mr. Philip McAlister, Director, Commercial Spaceflight Development Division, HEOMD. Mr. McAlister briefed the Committee on the status of commercial spaceflight. The Commercial Orbital Transportation Services (COTS) contract has been successfully completed and regular resupply missions to the ISS are in progress. The Commercial Crew Program (CCP) is concluding the Commercial Crew Integrated Capability (CCiCap) Space Act Agreements (SAAs). The Commercial Crew Transportation Capability (CCtCap) contract(s) for the final phase of Commercial Crew development are planned to be awarded in August or September. In August, NASA will award multiple no-exchange-of-funds SAAs for the Collaborations for Commercial Space Capabilities initiative. Mr. McAlister explained that the initiative may provide an additional partnering opportunity for U.S. private industry.

Mr. McAlister presented a chart on the Commercial Crew Acquisition Roadmap, showing mission milestones from 2010 through 2017. The CCiCap milestone status for Boeing, SpaceX, and Sierra Nevada Corporation (SNC) was reviewed. Slides were presented showing progress by those companies. Mr. McAlister noted that SNC and SpaceX have been given additional time to reach their milestones. In response to a question from Mr. Bowersox, Mr. McAlister explained that the milestone extensions would create no additional cost risks for NASA. Mr. Michael Lopez-Alegria commented that there is no cost to the government for extending SSAs.

In response to a question from Mr. Holloway, Mr. McAlister explained that the companies have different milestones because they have different development paths. He added that milestones do not have to be completed before a selection or selections are made for the CCtCap award. The CCtCap award schedule was discussed. Mr. McAlister noted that there is no linkage between CCiCap and CCtCap. The CCP Level I Risk Matrix was reviewed. The top three risks are: NASA costs may exceed NASA’s budget, NASA-unique requirements may drive costs up, and there may be a lack of competition. Mr. McAlister commented that he does not see a business case for deep space exploration. He noted that not all commercial space

flight development has to be overseen by his Division. In response to a question from Mr. Malow, Mr. McAlister explained that each awardee under CCTCap would receive a minimum of two missions if they complete certification and that NASA could increase that to as many as six missions.

Mr. Bowersox thanked Mr. McAlister for his presentation.

#### Status of International Space Station

Mr. Bowersox introduced Mr. Dan Hartman, Deputy Manager, ISS Program. Mr. Hartman briefed the Committee on the status of the ISS United States On-orbit Segment (USOS). He presented a chart on planned ISS port utilization. The status of ISS consumables was reviewed. Photographs of the 38 and 39 Soyuz crews were shown. The objectives for Expedition 40, crew utilization time, and the research performed during increments 39 and 40 were discussed. Mr. Hartman noted that during the previous week, the crew spent a record 84 hours on research. The average is 35 hours per week. He described the first rodent research on ISS—Rodent Research (RR)-1—and presented a chart showing a generic RR concept of operations. He noted that NASA plans to launch live animals on every other SpaceX mission.

Mr. Hartman discussed charts on two ISS vehicle issues. Micrometeoroid orbital debris (MMOD) recently struck the ISS's P4 Photovoltaic Radiator (PVR). A one millimeter particle is believed to have caused a tear 5.6 inches long. The Water Processing Assembly (WPA) filtration beds have incurred Total Organic Compound (TOC) breakthrough. Mr. Hartman reviewed the ISS Top Program Risk Matrix. The highest risk continues to be lack of assured access to the ISS. The next highest risks are pension harmonization and operations budget reduction. He briefed the Committee on the mission status of Orbital-2, Orbital-3, Automated Transfer Vehicle (ATV)-5, SpaceX-4, and SpaceX-5. He described a mishap investigation into what caused water to leak into an Extravehicular Mobility Unit (EMU) helmet during a spacewalk last year. The prime suspect is a filter that had not been properly cleaned. However, EMU 3011 may have unique characteristics that made it more susceptible to the contamination produced by the filter. To date, the investigation has produced 49 findings. Mr. Hartman explained that the critical findings of the investigation must be addressed before nominal spacewalks can be resumed.

Mr. Lopez-Alegria requested information on the crew rotation plan for when commercial crews are integrated. In response to a question from Mr. Bowersox about commercial crew integration, Mr. Hartman explained that maintaining a mixed crew (Russians and USOS crewmembers) provides the best protections for operating the Russian and USOS segments of the ISS following an unplanned departure of a return vehicle with a crew. To preserve this capability, Russian cosmonauts would need to launch on commercial crew vehicles and USOS crewmembers would continue to be launched on Soyuz. He noted that this would effectively be a seat for a seat arrangement. Agreement across the partnership for this approach is forward work. In response to a question from Mr. Malow, Mr. Hartman explained that Russia's budget for the ISS extends through 2020. All international partners have discussed extension through 2024, however, they are going through their respective government review cycles and cannot commit until approval is reached. He noted significant work is underway to extend the ISS to 2028. Mr. Hartman concluded by commenting that NASA's relationship with Russia remains the same as it has always been.

Mr. Bowersox thanked Mr. Hartman for his presentation.

Public Comments and Inputs

Comments from the public were invited. There were none.

Adjournment

The meeting was adjourned at 5:00 p.m.

**July 29, 2014**Call to Order

Dr. Bette Siegel called the HEO Committee meeting to order at 9:03 a.m. She welcomed everyone. New WebEx information was provided. She noted that presentations and minutes would be posted on line. Ms. Siegel then turned the meeting over to Mr. Bowersox.

Discussion and Recommendations

Mr. Bowersox explained that the NAC Chair has asked the Committee develop a full consensus recommendation that reflects concerns over the SLS flight rate. Another item for the Committee to work on is whether to endorse NASA's current approach to the Human Exploration Strategy. This could be a straight endorsement, an endorsement plus emphasis on elements that the Committee particularly approves, or an endorsement on individual elements.

Mr. Bowersox presented a proposed recommendation on the SLS flight rate for the Committee to consider:

*The NAC recommends that NASA conduct a trade study to determine an optimal launch rate for the SLS with respect to cost, safety, mission success and performance. As part of the trade study, NASA should examine approaches to achieve the optimal launch rate within the current funding profile.*

Mr. Holloway advised that the real problem is finding enough customers for the optimal rate. Mr. Lopez-Alegria commented that unless NASA defines the criteria, cost, or safety, there is nothing to trade. He added that this is a "cry for help" to get more money. Dr. Condon explained that NASA needs to acknowledge the scope of the problem and then determine the necessary funding level. Mr. Bowersox noted that setting a minimum rate would also be valuable. Mr. Odom advised that there would be a great risk to the supplier chain if the launch rate was only once per year.

Dr. Siegel announced new WebEx information.

Dr. Condon explained that word "optimal" has different meanings. It may mean the launch rate required to ensure a reasonable degree of safety and mission success. Alternatively, it may mean the most cost-effective rate that ensures mission success and safety. Mr. Odom recommended replacing the word

optimal with “minimal.” Mr. Lopez-Alegria commented that a discussion about an optimum rate is meaningless because NASA would be lucky to get funding for a minimum rate. Mr. Williams noted that NASA wants to fly the SLS at least once a year, and is designing to a surge capacity of 3 per year. He added that the considerations about the supply chain and cost are important. Mr. Lon Levin supported using the word “minimum.” He commented that there is also a need to leave in cost to show that it is understood and respected as an issue. He recommended eliminating the language about “current funding profile.”

Mr. Bowersox presented a proposed recommendation on the Exploration Strategy for the Committee to consider:

*The NAC endorses NASA’s current approach to Human Exploration as presented by the HEOMD Deputy Associate Administrator at the July 30<sup>th</sup> meeting of the Council.*

Mr. Bowersox explained that the NAC was not willing to endorse the strategy at the last NAC meeting due to concerns that there would not be sufficient funding. In response to his query as to the correct name for the strategy, Mr. Williams responded that it can be “Pioneering Space,” the “Evolving Mars Campaign,” or “Exploration Strategy.” Mr. Lopez-Alegria commented that he disagrees with the whole ARM, but recognized that it is the only way to proceed now and that it should be approved. Mr. Holloway commented that the Committee’s purpose should be to support the Administrator, because it cannot influence Congress. Mr. Levin asserted that the ARM is a great idea and that the focus should be on Mars.

Mr. Bowersox noted that the finding could simply address specific aspects about the Strategy that the Committee was willing to endorse. He presented 5 potential aspects:

1. Mars as a horizon goal for human space exploration;
2. an intermediate exploration goal which is affordable, and allows development of systems that can later be used for more distant exploration of the solar system;
3. an approach that emphasizes affordability and allows re-use of system components;
4. a flexible approach, which allows reassessment of goals and objectives as the US economy and technical capability develop with time; and
5. potential areas of involvement for commercial and international partners.

In response to a question from Mr. Malow, Mr. Bowersox explained that this finding stood a better chance for approval by the NAC than a finding that endorsed the entire strategy. Mr. Hale noted that the NAC is largely concerned with whether there is sufficient money. Dr. Condon explained that he would not discard the strategy just because it is not resourced. Dr. Siegel clarified that the strategy is called the “Evolvable Mars Campaign.” Mr. Williams noted that “Pioneering Space” is the overall umbrella and that it is an evolving story. Mr. Holloway observed that this issue would not be a discussion if the NRC had not issued its report. He added that NASA needs the Committee’s support to move forward and that the Committee should “either be for or against” that. Mr. Odom commented that NASA should concentrate on going back to the Moon. Mr. Lopez-Alegria added that there is much support in Congress for returning to the Moon.

Mr. Bowersox presented a revised proposed recommendation on the SLS launch rate. It was approved by the Committee as follows:

*The NAC recommends that NASA conduct a trade study to determine a minimum launch rate for the SLS with respect to cost, safety, mission success, and performance.*

The Committee discussed possible topics for future meetings. Mr. Bowersox announced that the next meeting would be held in November. Mr. Malow requested a briefing on the results of the rat experiment on cosmic ray impact. Mr. Levin requested a briefing on what work is going on elsewhere other than in NASA. Dr. Siegel explained that the GER covers that work. Mr. Levin noted that other nations handle procurement differently and that Europe is the most efficient. In response to a request from Mr. Cuzzupoli, Mr. Bowersox stated that updates on rocket engines would be a recurring topic for status briefings.

#### Wrap-up

Mr. Bowersox expressed his appreciation for everyone's participation. He commented that he tries to represent all opinions when he meets with the NAC.

#### Public Comments

Comments from the public were invited.

Mr. Chris Gilbert offered the following comment:

*The Committee has at various times expressed an interest in the exploration priorities and activities of potential international partners. NASA frequently refers to international cooperation as a key enabling element of the U.S. exploration strategy, but is not in a position to say what specific contributions international partners will make to support NASA's human exploration missions. In my opinion, this presents a hindrance to the NAC's efforts to evaluate NASA's capability of fulfilling Administration and Congressional expectations. Since November 2007, NASA, together with 13 international Agency partners, has engaged in an exchange of ideas on international space exploration endeavors in a forum known as the International Space Exploration Coordination Group (ISECG). The latest output of this group is the Global Exploration Roadmap, Version 2.*

*I would like to suggest that the Committee invite NASA to report on its international space exploration cooperation activities and achievements, with special regard to exploration plans and policies of the ISECG international partners. In particular, it may be useful for the Committee to know what next steps the potential partners intend to undertake, and how these are being harmonized with NASA's current and planned activities. Since the international partner agencies may not wish their ISECG discussions to be made public, NASA could present international plans in a way that does not reveal specific national planning that is not already public, but rather in a way that highlights the overall exploration logic and priorities of the international community at large. The global exploration capability and the extent to which it can be leveraged to achieve U.S. and international goals can then be better understood.*

Mr. Bowersox thanked Mr. Gilbert for his comments.

There were no other comments from the public.

Adjournment

Dr. Siegel adjourned the Committee meeting at 11:30 a.m.

**NASA ADVISORY COUNCIL**  
**Human Exploration and Operations Committee Meeting**  
**Langley Research Center**  
**5 Langley Boulevard**  
**Building 2101, Room 305**  
**Hampton, VA 23669**  
**July 28-29, 2014**

**AGENDA**

**July 28** (NAC Science/Human Exploration and Operations Committee Joint Session)

**Committee Public Meeting**

9:30 – 9:40 am	Opening Remarks	Mr. Ken Bowersox, NAC Human Exploration and Operations Chair & Dr. Bette Siegel, Executive Secretary Dr. David McComas, NAC Science Chair & Dr. Jens Feeley, Executive Secretary
9:40 – 10:40 am	Joint Session with NAC Science Committee	Dr. Jim Green Director, Planetary Science, Science Mission Directorate
10:40 – 11:20 am	Space Launch System & Discussion	Mr. Bill Hill Deputy Associate Administrator for Exploration Systems Development, Human Exploration and Operations Mission Directorate
11:20 am – 12:00 pm	Joint Discussion of Findings and Recommendations	
12:00 – 12:10 pm	Center Welcome & Remarks	Mr. Stephen Jurczyk, Director, Langley Research Center
12:10 – 1:10 pm	<b><u>JOINT LUNCH</u></b>	
1:10 – 1:20 pm	<b><u>BREAK</u></b>	
1:20 – 2:20 pm	HEO Status and Plans	Mr. Greg Williams Deputy Associate Administrator for Policy & Plans, Human Exploration and Operations Mission Directorate
2:20 – 3:20 pm	Status of Commercial Crew	Mr. Phil McAlister Director, Commercial Spaceflight, Human Exploration and Operations Mission Directorate
3:20 – 3:40 pm	<b><u>BREAK</u></b>	
3:40 – 4:50 pm	Status of International Space Station	Mr. Dan Hartman Deputy Manager, International Space Station Program
4:50 – 5:00 pm	Public Comments and Inputs	
5:00 pm	<b><u>ADJOURN</u></b>	



**July 29**

**Committee Public Meeting**

9:00 – 9:05 am	Opening Remarks	Mr. Ken Bowersox, NAC Human Exploration and Operations Chair & Dr. Bette Siegel, Executive Secretary
9:05 – 11:25 am	Discussion and Recommendations	
11:25 – 11:30 am	Public Comments	
11:30 am	<b><u>ADJOURN</u></b>	

**Human Exploration and Operations Committee Membership  
July 2014**

Mr. Ken Bowersox <i>Chair</i>	Former NASA astronaut and retired U.S. Navy Captain
Dr. Bette Siegel <i>Executive Secretary</i>	NASA Headquarters
Ms. Shannon Bartell	Former Director of Safety & Mission Assurance, KSC
Ms. Nancy Ann Budden	Director for Special Operations Technology, Office of the Secretary of Defense
Dr. Leroy Chiao	Former NASA Astronaut and ISS Commander
Dr. Stephen "Pat" Condon	Aerospace Consultant, former Commander of the Ogden Air Logistics Center, the Arnold Engineering Development Center, and the Air Force Armament Laboratory
Mr. Joseph Cuzzupoli	Former Assistant Apollo Program Manager, Rockwell, and manager of the Space Shuttle Orbiter Project
Mr. Tommy Holloway	Former Space Shuttle and ISS Program Manager
Mr. Lon Levin	President, SkySevenVentures
Dr. David E. Longnecker	Director, Health Care Affairs, Association of American Medical Colleges (AAMC), member of the National Academy of Sciences Institute of Medicine (IOM)
Mr. Michael Lopez-Alegria	Former NASA astronaut and retired U.S. Navy Captain, President of the Commercial Spaceflight Federation
Mr. Richard Malow	Distinguished Advisor at the Association of University for Research in Astronomy (AURA)
Mr. James Odom	Former NASA Associate Administrator for Space Station Freedom
Mr. Bob Sieck	Former Space Shuttle Launch Director
Mr. James Voss	Former NASA astronaut and retired U.S. Army Colonel, Scholar in Residence, Department of Aerospace Engineering Sciences, University of Colorado, Boulder

**Human Exploration and Operations Committee  
Langley Research Center  
Hampton, Virginia**

**July 28-29, 2014**

**MEETING ATTENDEES**

*Committee Members:*

Bowersox, Ken, <i>Chair</i>	U.S. Navy ( <i>Ret.</i> )
Siegel, Bette, <i>Executive Secretary</i>	NASA Headquarters
Condon, Stephen "Pat"	Aerospace Consultant
Cuzzupoli, Joseph ( <i>via telecon</i> )	Aerospace Consultant
Holloway, Tommy	Aerospace Consultant
Levin, Lon	SkySevenVentures
Lopez-Alegria, Michael	Commercial Spaceflight Federation
Malow, Richard	AURA
Odom, James	Aerospace Consultant

*NASA Attendees:*

Creech, Steve	NASA Headquarters
Feeley, T. Jens	NASA Headquarters
Green, Jim	NASA Headquarters
Grunsfeld, John	NASA Headquarters
Hartman, Dan	NASA Headquarters
Hill, Bill	NASA Headquarters
Jurczyk, Stephen	NASA LaRC
Kennedy, Eracenia	NASA Headquarters
McAlister, Philip	NASA Headquarters
Robinson, Shawanda	NASA Headquarters
Williams, Greg	NASA Headquarters

*Other Attendees:*

Brabscerez, Darrell	<i>[not affiliated]</i>
Duncan, Doug	NAC Science Committee
Frankel, David	PB Frankel, LLC
Hagar, Maura	NAC Science Committee
Hale, Wayne	NAC
Karanian, Linda	RPC
McComas, David	NAC Science Committee
Robinson, Mark	NAC Science Committee
Running, Steve	NAC Science Committee
Spence, Harlan	NAC Science Committee

*Telecon and WebEx Attendees:*

Allen, Gale  
Barbier, Louis  
Branscome, Darrell  
Bryant, Devin  
Condes, Albert  
Dean, James  
Delo, Ann  
Dittmer, Mary Lynne  
Gates, Michele  
Gaudi, Scott  
Gilber, Chris  
Graham, Sandra  
Grau, Raphael  
Hinnners, Noel  
Holle, Marchel  
Irving, Richard  
Kerns, Robert  
Libel, Greg  
Lochner, James  
Luhmann, Janet  
Martin, Amaya Moro  
McMillian, Shandy  
McSween, Hap  
Miller, Matthew  
Moloney, Michael  
Neal, Cynthia  
Nittner II, Jeurgan  
Pieters, Carle  
Pugel, Betsy  
Schrier, Joey  
Schwerin, Theresa  
Smith, Marcia  
Sweet, Anne  
Westhelle, Carlos  
Whitmeyer, Thomas

**Human Exploration and Operations Committee  
Langley Research Center  
Hampton, Virginia**

**July 28-29, 2014**

**LIST OF PRESENTATION MATERIAL**

- 1) HEO and SMD Joint Activities [Green]
- 2) NASA Advisory Council HEO Committee [Williams]
- 3) NASA's Space Launch System: A Revolutionary Capability for Science [Hill & Creech]
- 4) Commercial Spaceflight Development Update [McAlister]
- 5) Status of the ISS USOS [Hartman]